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Huang et al.

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(54) **LAMINATED WAVEGUIDE DIPLEXER WITH SHIELDED SIGNAL-COUPLING STRUCTURE**

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(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**
H01P 3/12 (2006.01)
H01P 1/213 (2006.01)
H01P 5/107 (2006.01)

(52) **U.S. Cl.**
CPC ***H01P 1/2138*** (2013.01); *H01P 5/107* (2013.01)

(58) **Field of Classification Search**
USPC 333/239, 248, 125–126, 132; 343/771–772, 767
See application file for complete search history.

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Primary Examiner — An Luu

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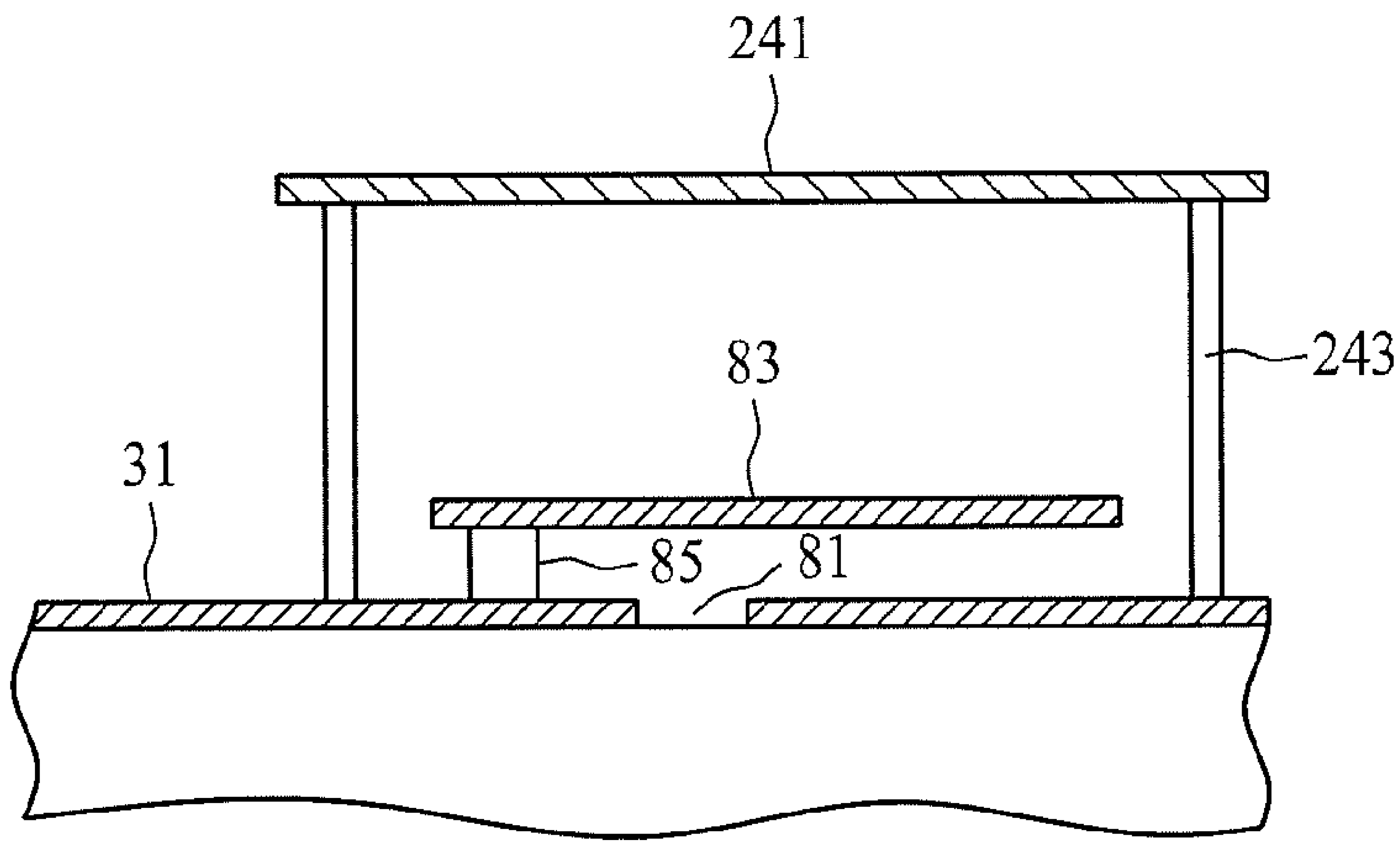
(57) **ABSTRACT**

A laminated waveguide diplexer includes an upper conductive layer having a first slot and a second slot; a first line crossing over the first slot; a first shielding conductor disposed over the first line; a plurality of first conductive pillars connecting the upper conductive layer and the first shielding conductor; a second line crossing over the second slot; a second shielding conductor disposed over the second line; and a plurality of second conductive pillars connecting the upper conductive layer and the second shielding conductor.

18 Claims, 13 Drawing Sheets



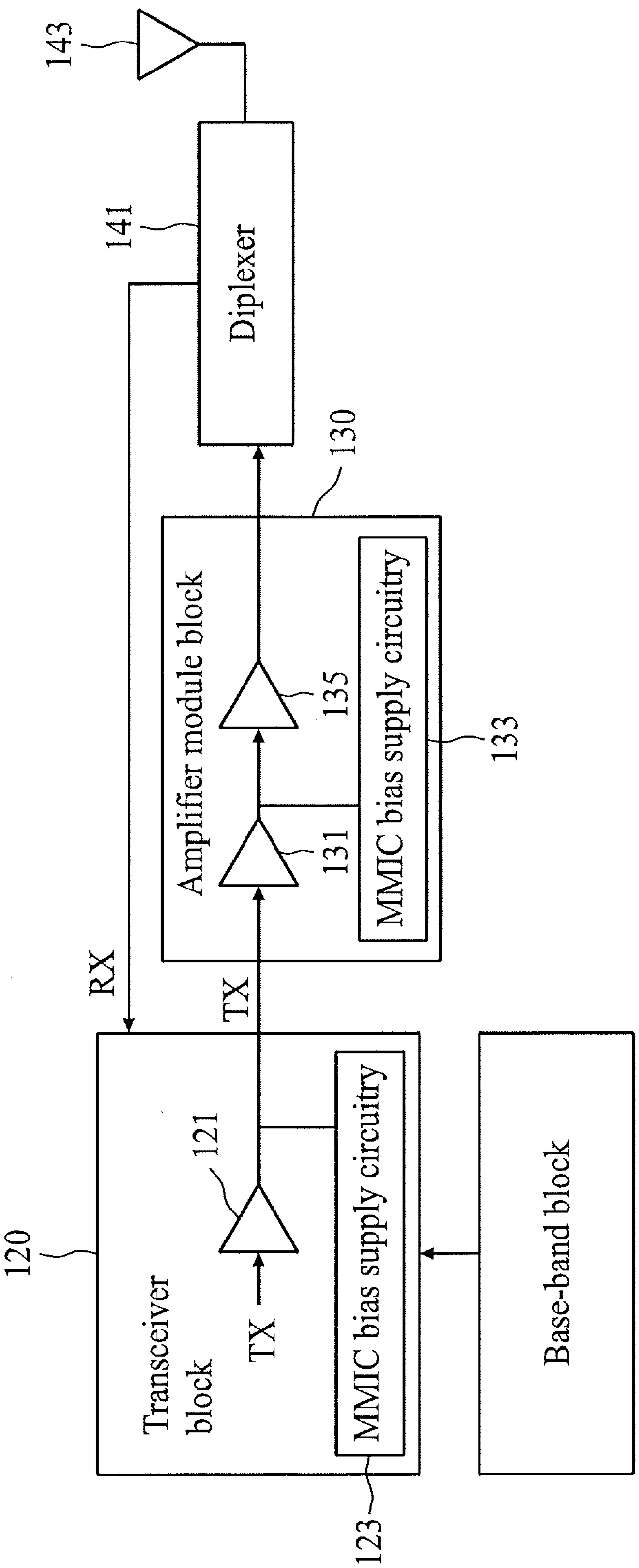

143
Diplexer
141
130
Amplifier module block
135
131
MMIC bias supply circuitry
133
RX
TX
Transceiver block
121
120
TX
MMIC bias supply circuitry
123
Base-band block

FIG. 1

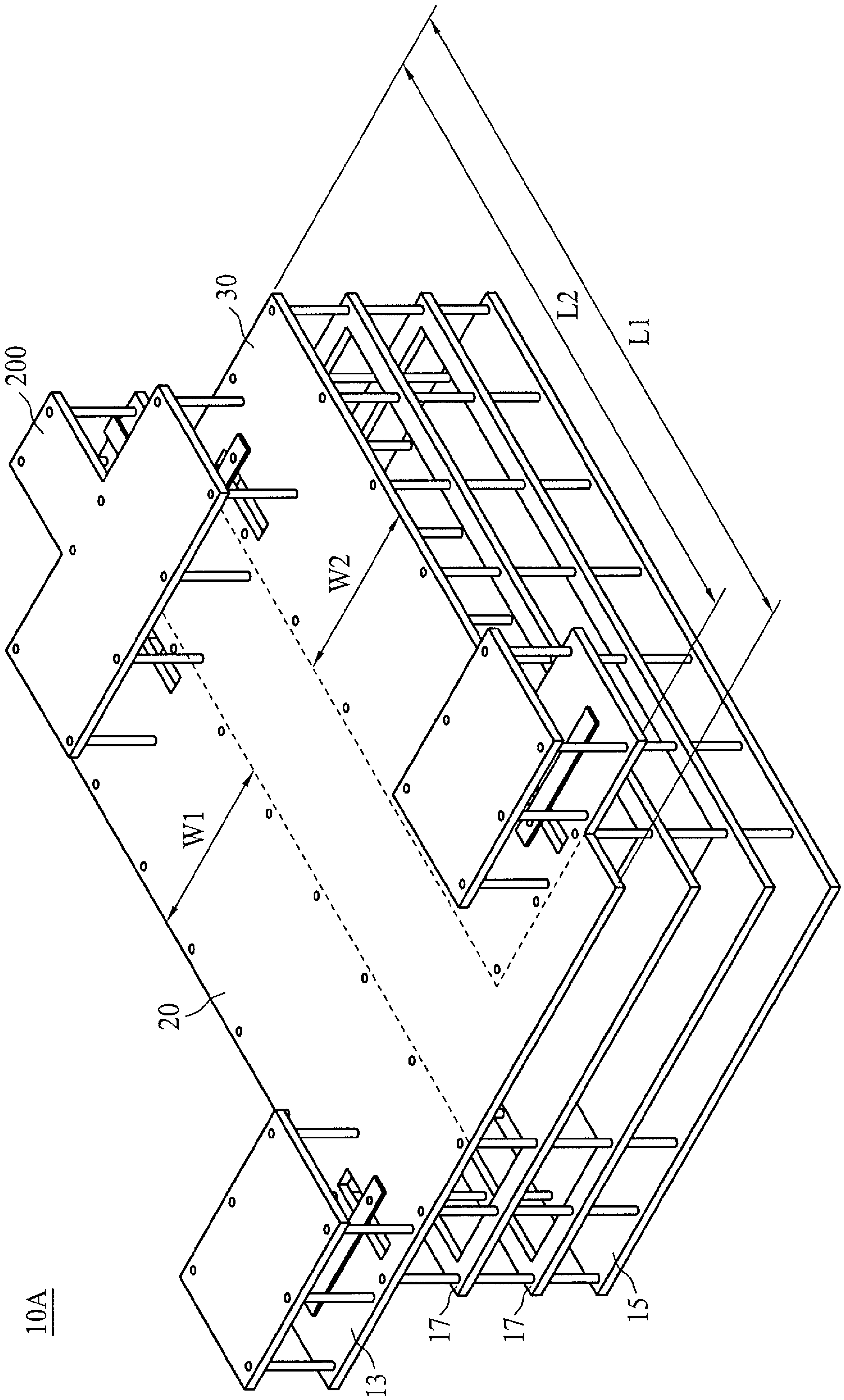


FIG. 2

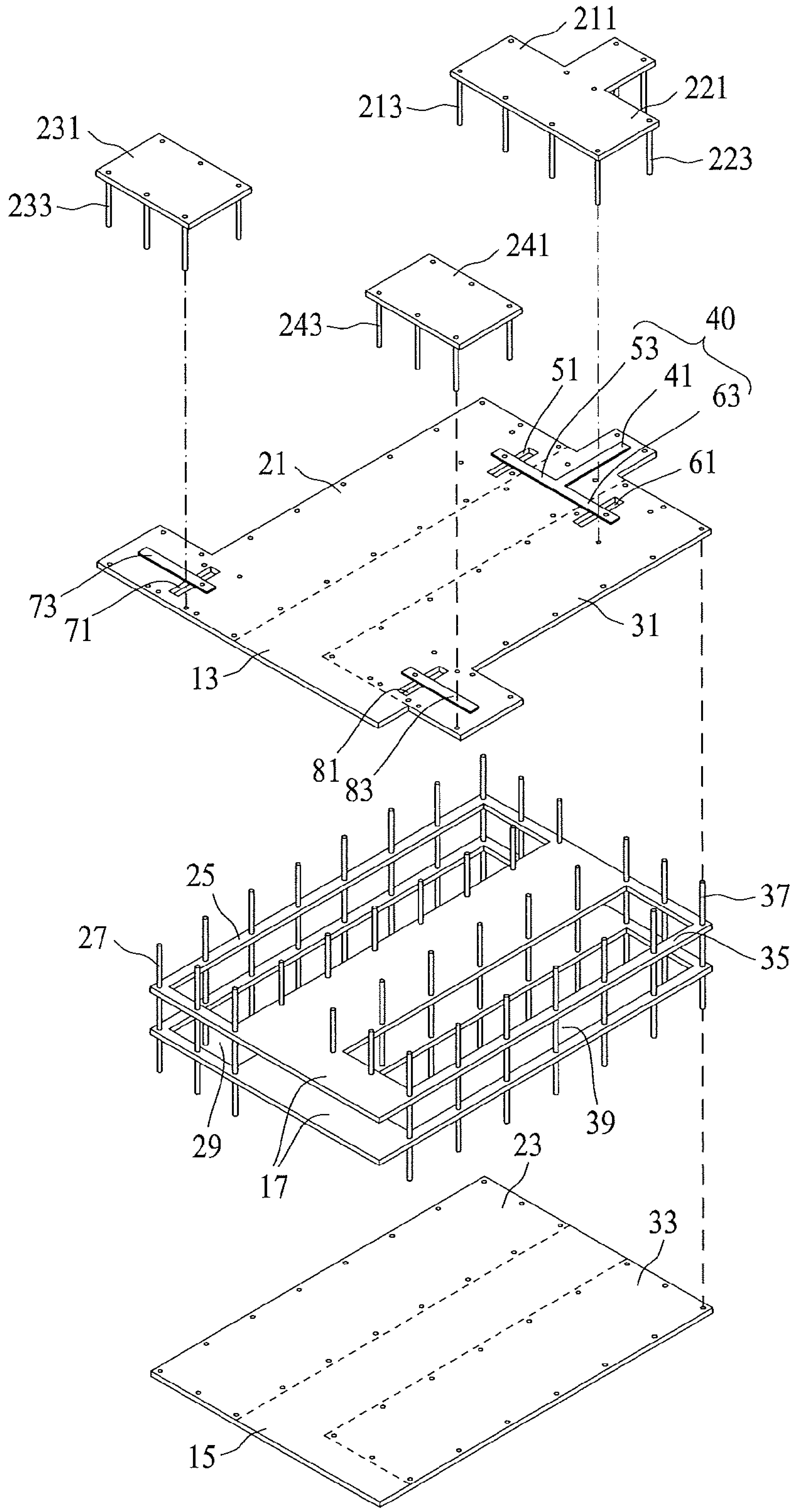

211
213
221
223
231
233
241
243
40
53
51
41
63
61
21
73
71
31
13
81
83
37
25
27
35
29
39
17
23
33
15

FIG. 3

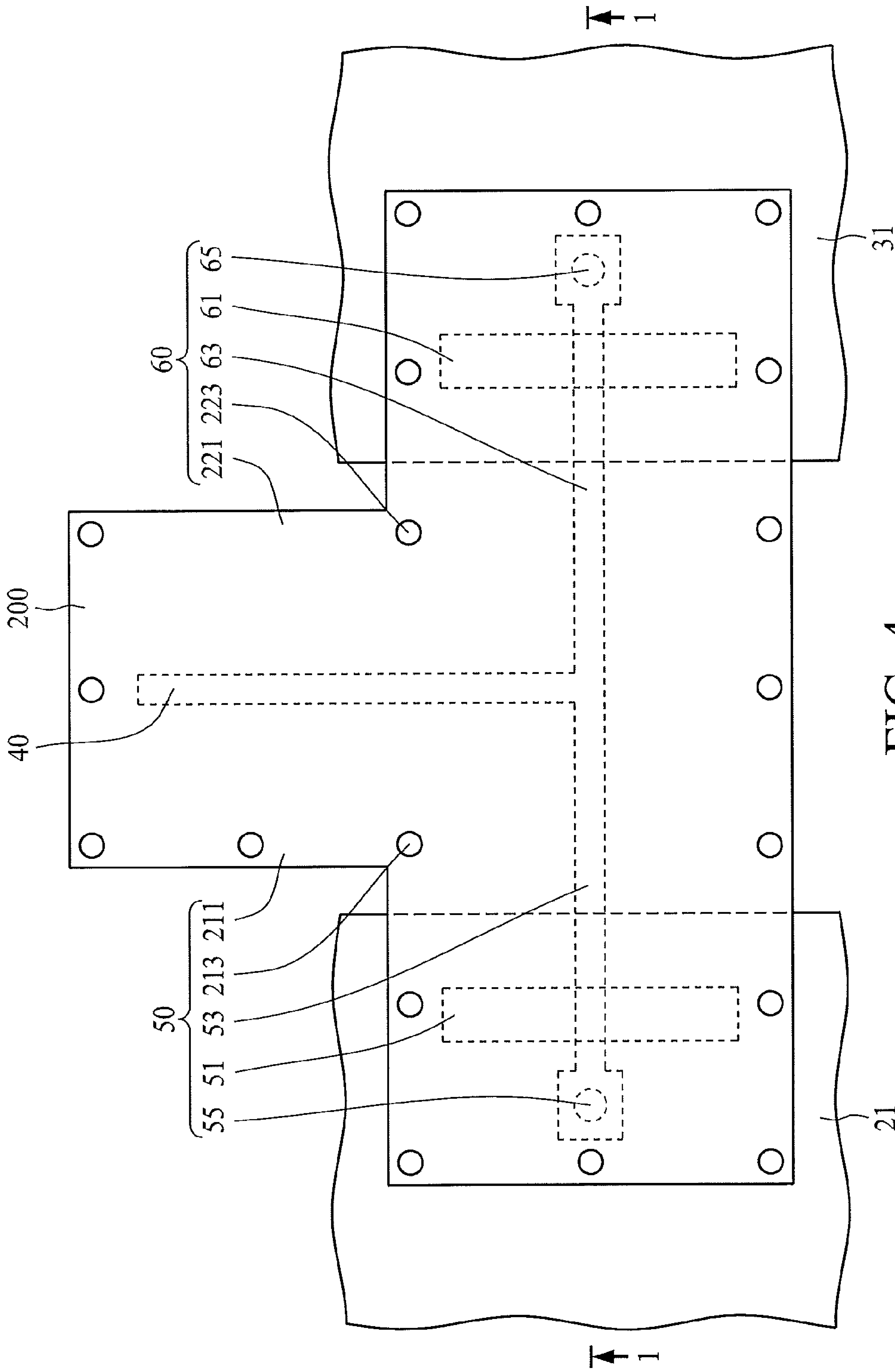


FIG. 4

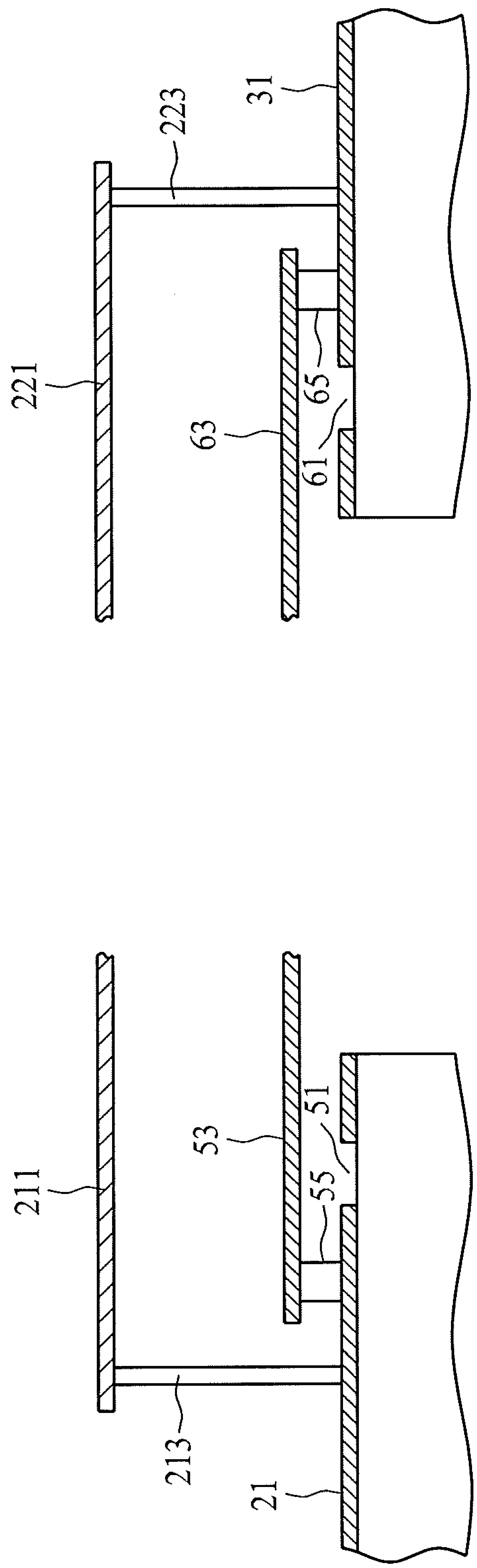


FIG. 5

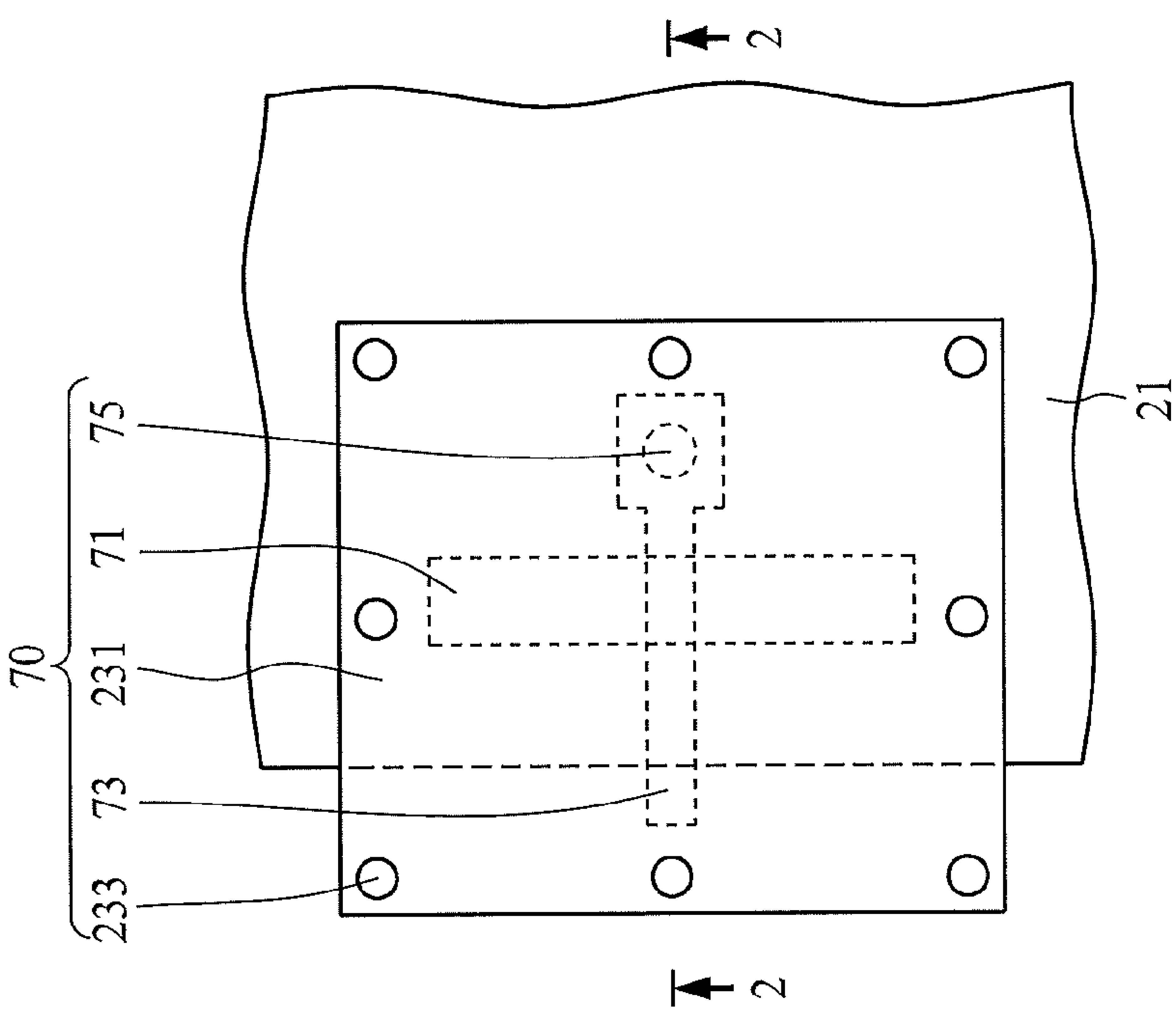


FIG. 6

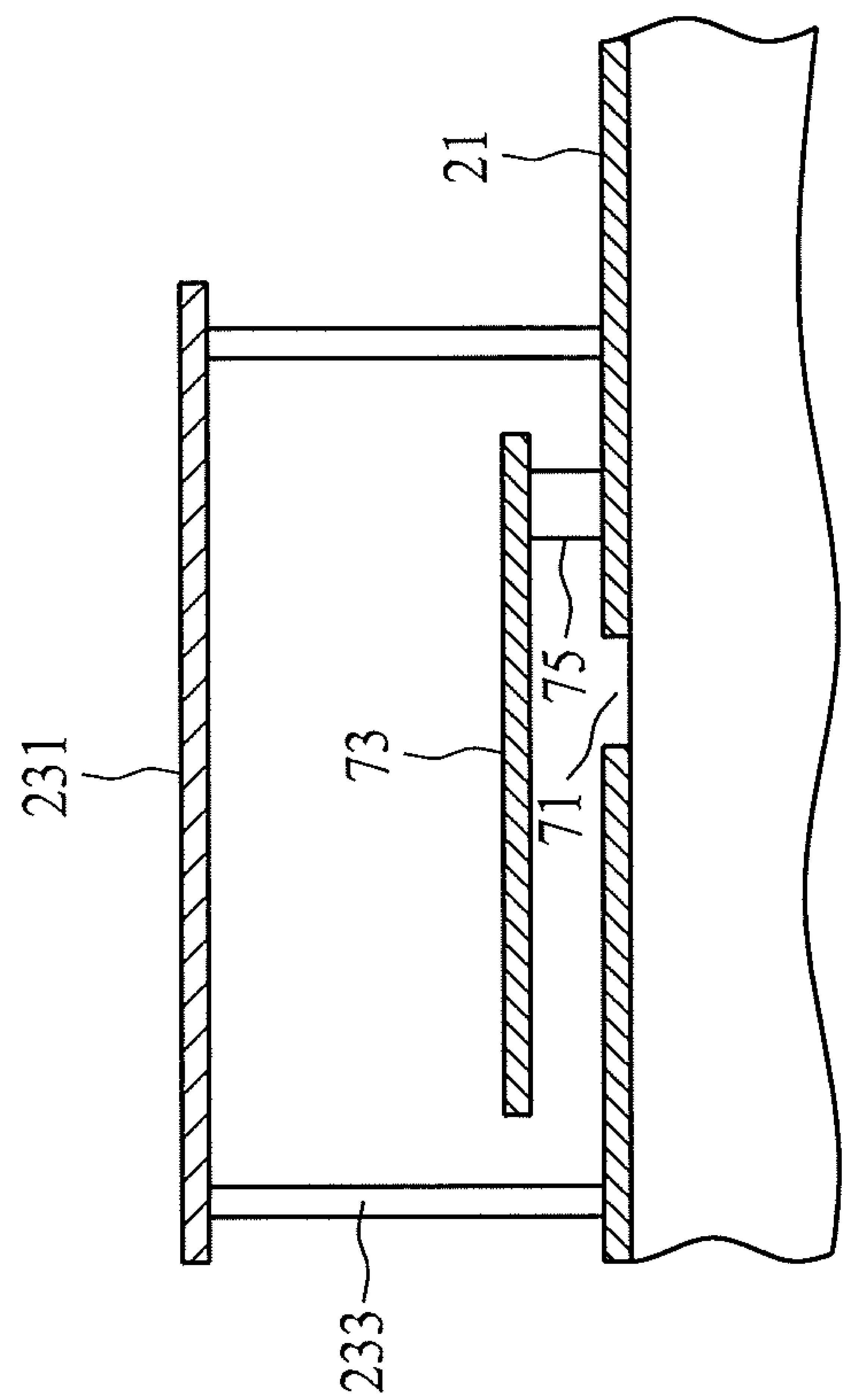


FIG. 7

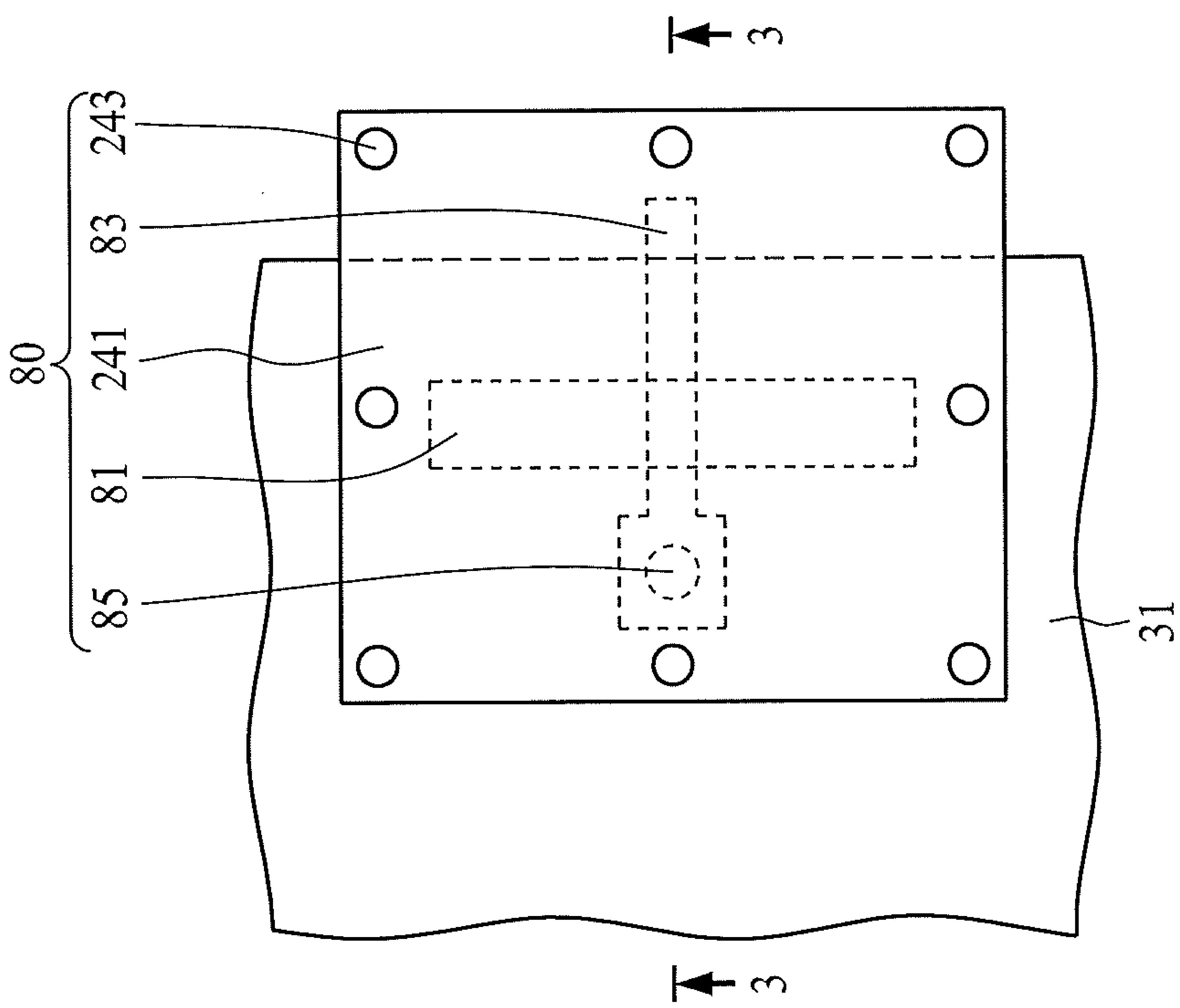


FIG. 8

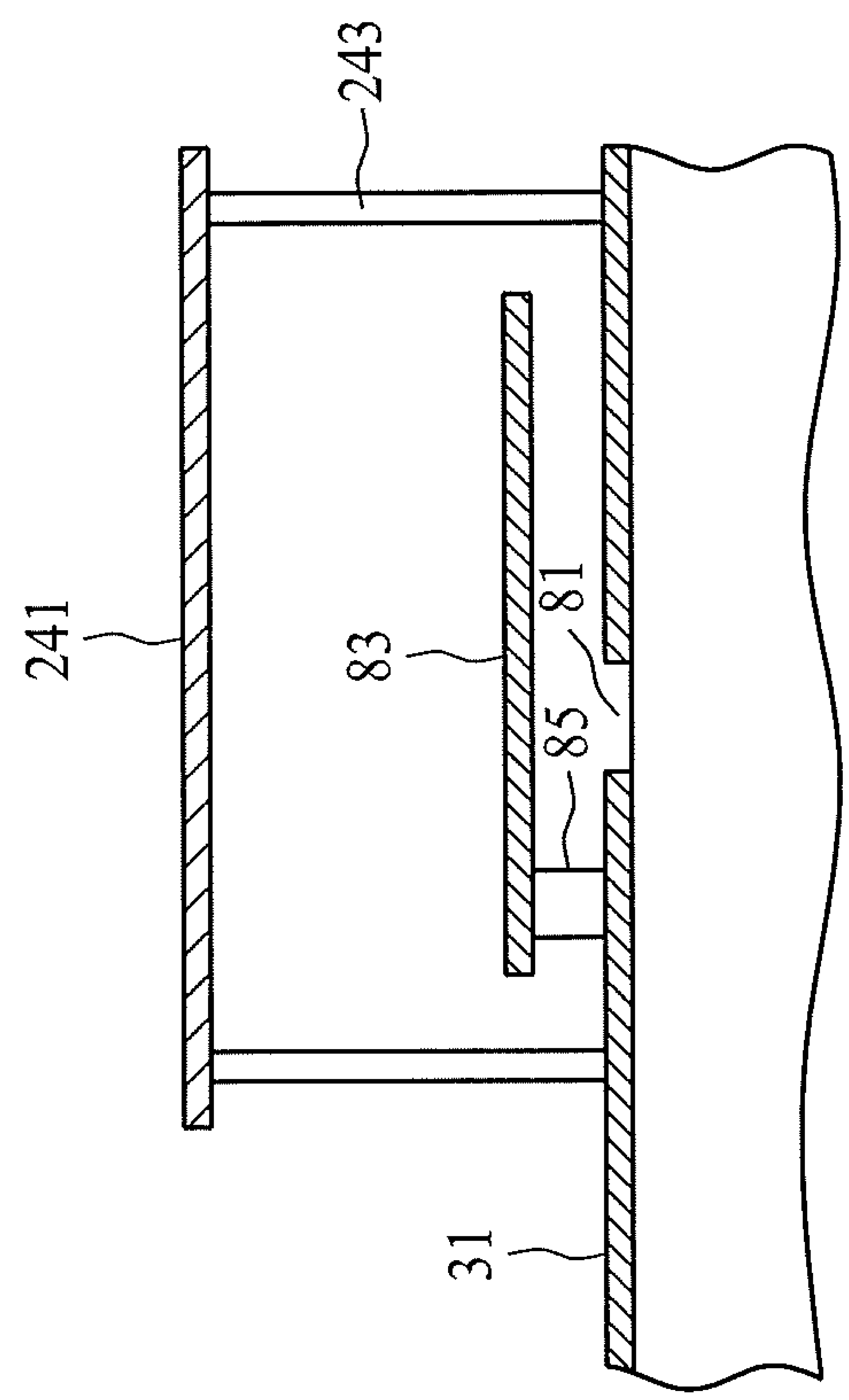


FIG. 9

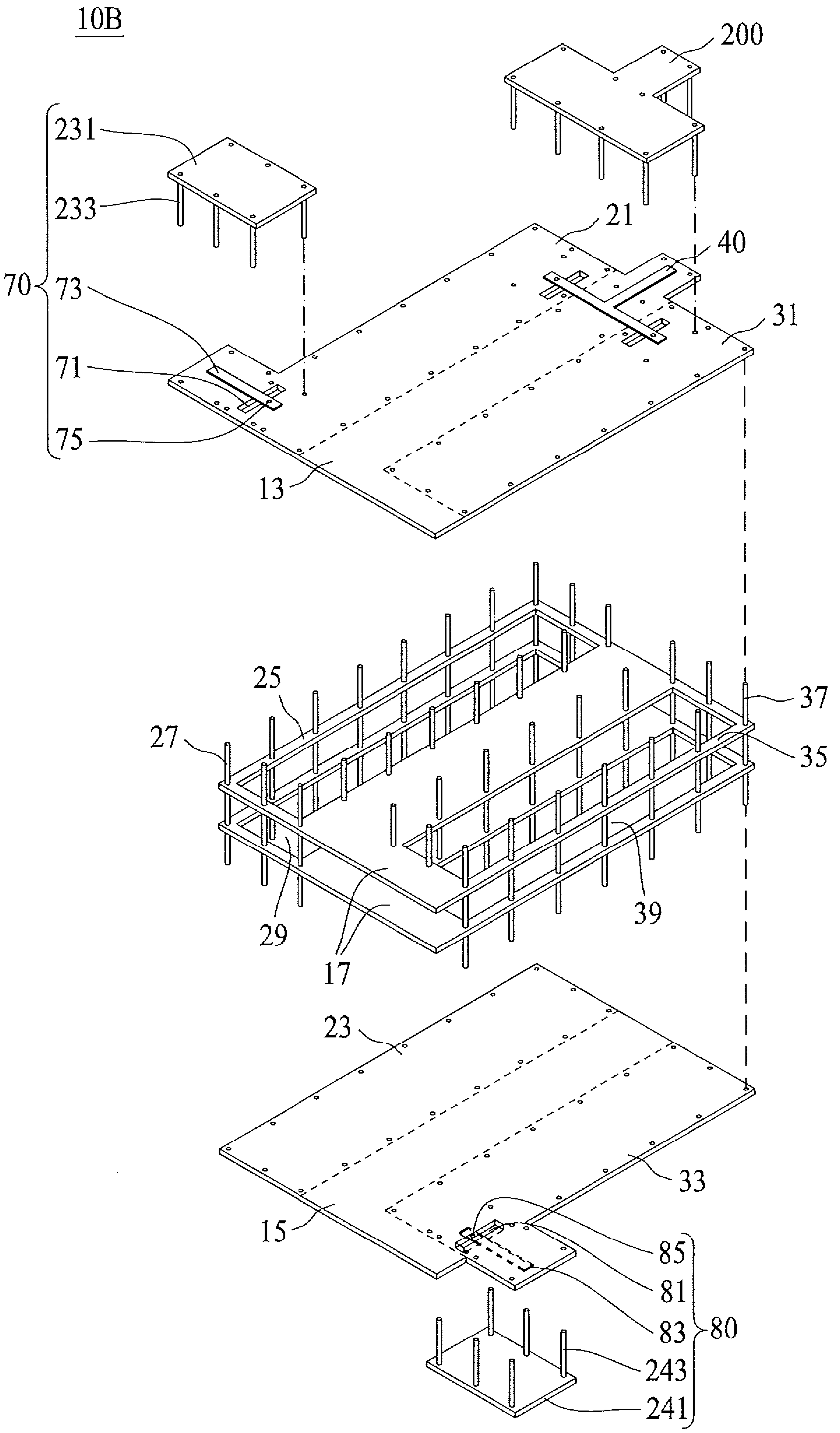

10B
200
231
233
21
40
70
73
31
71
75
13
25
37
27
35
39
29
17
23
33
15
85
81
83
80
243
241

FIG. 10

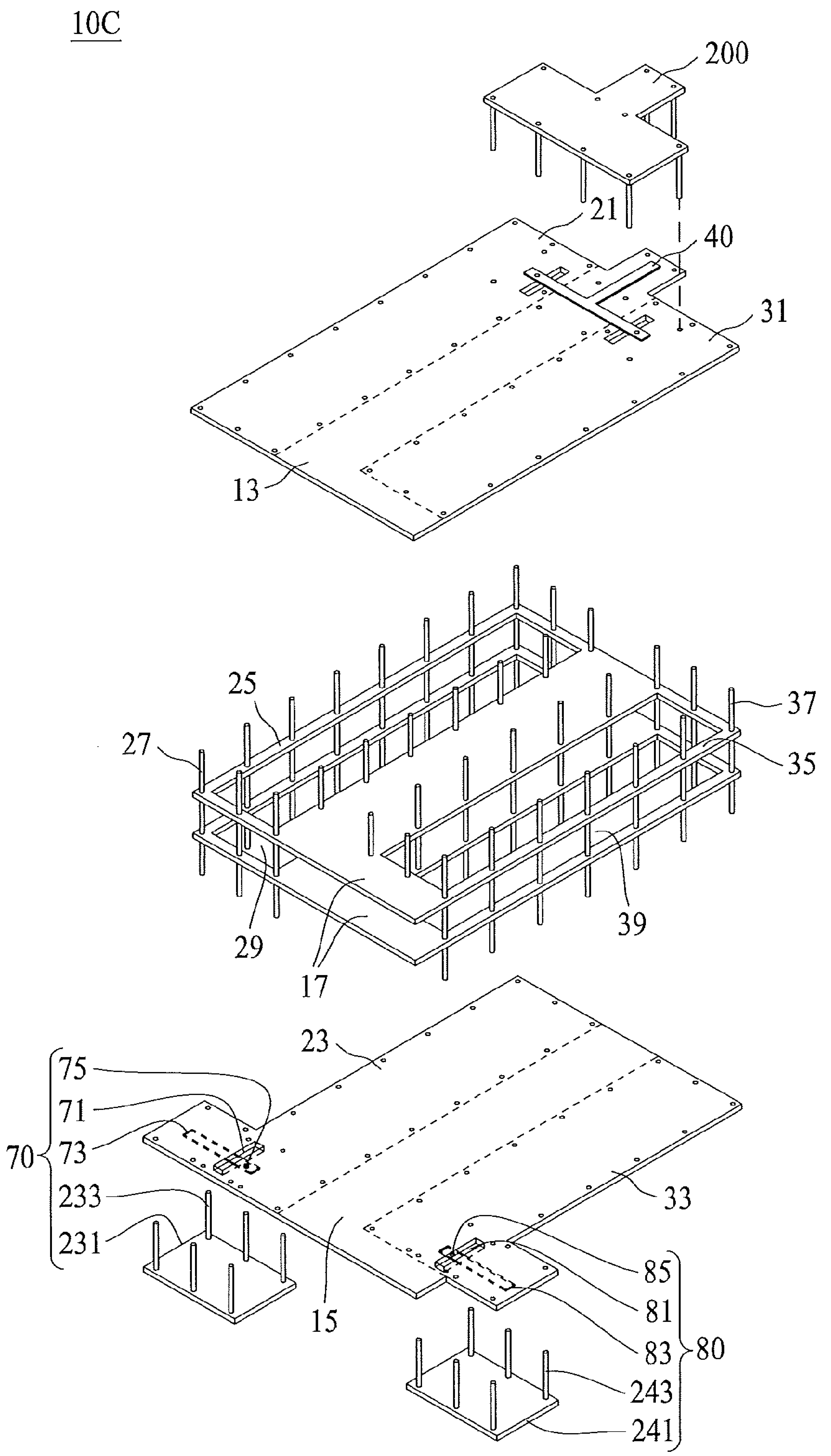
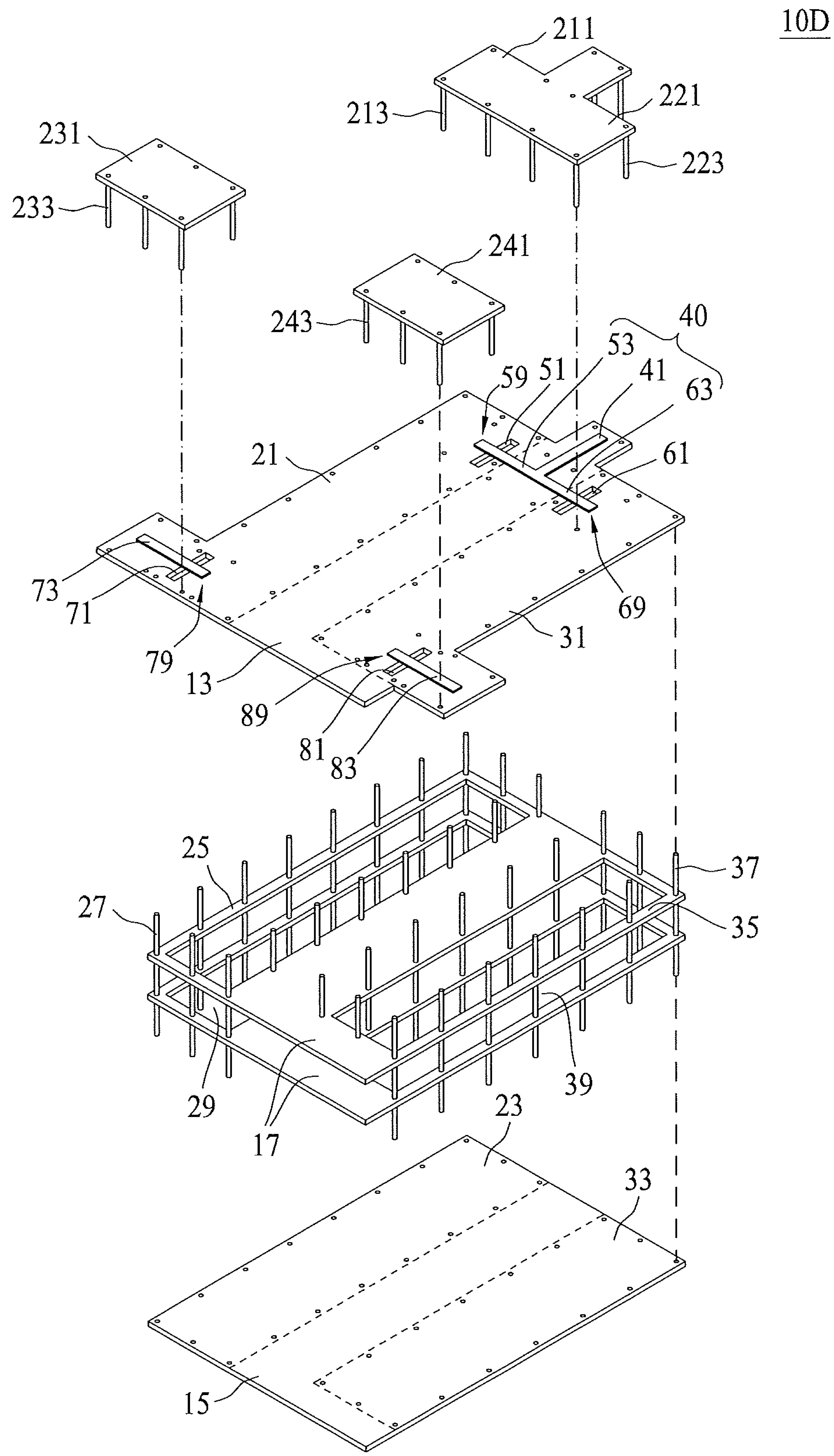

10C
200
21
40
31
13
25
37
27
35
29
39
17
23
75
71
73
70
233
231
33
85
81
83
80
15
243
241

FIG. 11


10D
211
213
221
223
231
233
241
243
40
53
51
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41
63
61
21
73
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79
69
31
13
89
81
83
25
37
27
35
29
39
17
23
33
15

FIG. 12

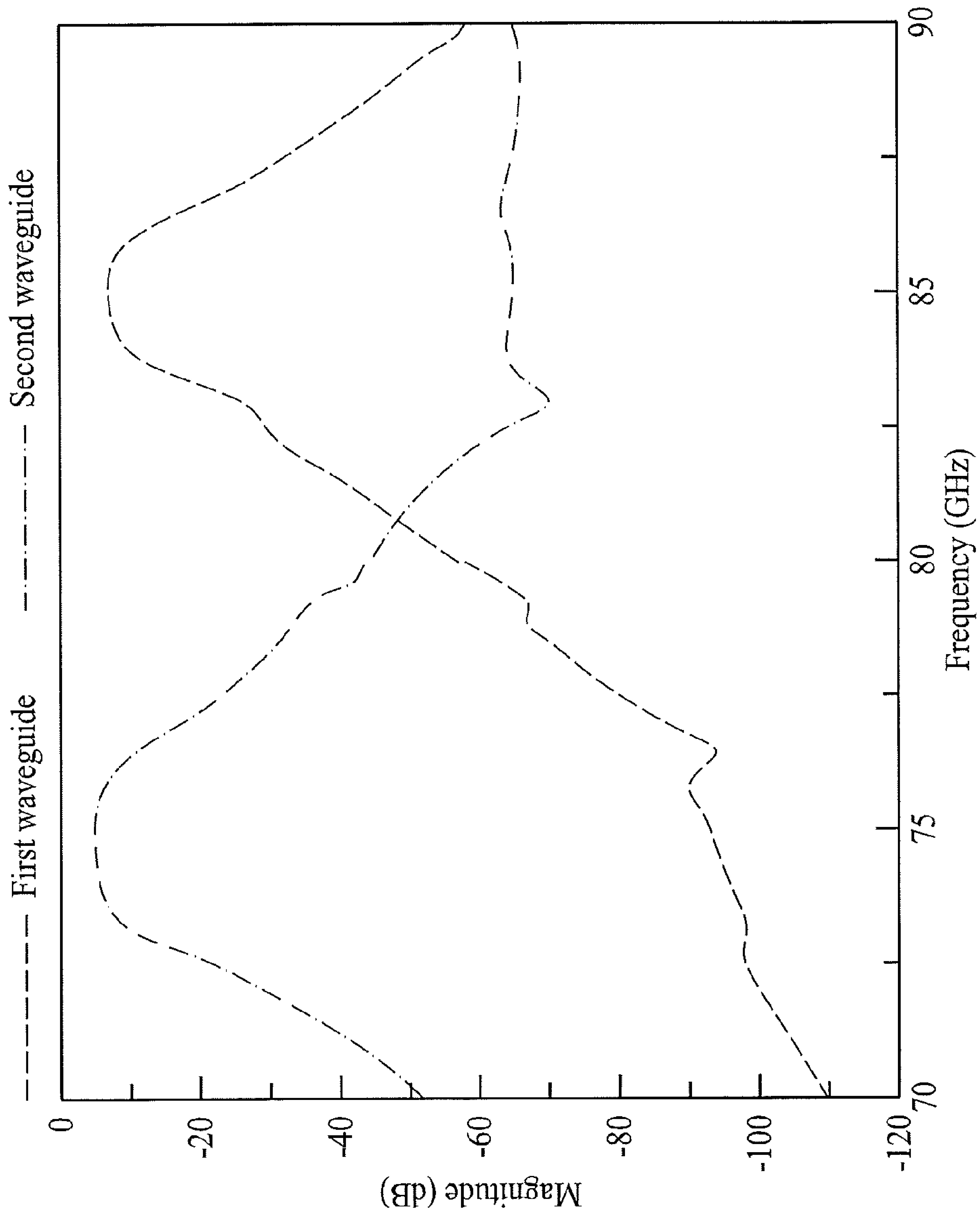
First waveguide
Second waveguide
Magnitude (dB)
0
-20
-40
-60
-80
-100
-120
70
75
80
85
90
Frequency (GHz)

FIG. 13

LAMINATED WAVEGUIDE DIPLEXER WITH SHIELDED SIGNAL-COUPLING STRUCTURE

FIELD OF THE INVENTION

The present disclosure relates to a laminated waveguide diplexer with a shielded signal-coupling structure for transmitting and receiving radio frequency signals on different frequency bands.

DISCUSSION OF THE BACKGROUND

Wireless communication systems are widely deployed to provide various communication content such as voice, video, packet data, messaging, broadcast, etc. These wireless systems may be multiple-access systems capable of supporting multiple users by sharing the available system resources. Examples of such multiple-access systems include Code Division Multiple Access (CDMA) systems, Time Division Multiple Access (TDMA) systems, Frequency Division Multiple Access (FDMA) systems, Orthogonal FDMA (OFDMA) systems, and Single-Carrier FDMA (SC-FDMA) systems.

In some communication systems, it is highly desirable to operate in two widely separated frequency bands instead of a single frequency band. This is due to the cost of implementing communication systems to meet system requirements, such as power, bandwidth, and federal regulatory limitations.

This “Discussion of the Background” section is provided for background information only. The statements in this “Discussion of the Background” are not an admission that the subject matter disclosed in this “Discussion of the Background” section constitutes prior art to the present disclosure, and no part of this “Discussion of the Background” section may be used as an admission that any part of this application, including this “Discussion of the Background” section, constitutes prior art to the present disclosure.

SUMMARY

One aspect of the present disclosure provides a laminated waveguide diplexer with a shielded signal-coupling structure for transmitting and receiving radio frequency signals on different frequency bands.

A laminated waveguide diplexer according to this aspect of the present disclosure comprises an upper conductive layer having a first slot and a second slot; a first line crossing over the first slot; a first shielding conductor disposed over the first line; a plurality of first conductive pillars connecting the upper conductive layer and the first shielding conductor; a second line crossing over the second slot; a second shielding conductor disposed over the second line; and a plurality of second conductive pillars connecting the upper conductive layer and the second shielding conductor.

The first shielding conductor and the first conductive pillars form a first shielded signal-coupling structure for a signal line (the first line) of a first laminated waveguide; similarly, the second shielding conductor and the second conductive pillars form a second shielded signal-coupling structure for a signal line (the second line) of a second laminated waveguide.

Due to the utilization of the shielding conductors over the signal lines of the laminated waveguide diplexer, the first radio frequency signals propagating through the first laminated waveguide are substantially not influenced by the second radio frequency signals propagating through the second laminated waveguide, and the second radio frequency signals

propagating through the second laminated waveguide are substantially not influenced by the first radio frequency signals propagating through the first laminated waveguide. As a result, the laminated waveguide diplexer can operate in two separated frequency bands instead of a single frequency band; for example, the laminated waveguide diplexer can use one of the two laminated waveguides to receive the radio frequency signals on a first frequency band and use another laminated waveguide to transmit the radio frequency signals on a second frequency band.

The foregoing has outlined rather broadly the features and technical advantages of the present disclosure in order that the detailed description of the disclosure that follows may be better understood. Additional features and advantages of the disclosure will be described hereinafter, which form the subject of the claims of the disclosure. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures or processes for carrying out the same purposes of the present disclosure. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the disclosure as set forth in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present disclosure may be derived by referring to the detailed description and claims when considered in connection with the Figures, where like reference numbers refer to similar elements throughout the Figures, and:

FIG. **1** shows an RF lineup block diagram depicting amplification of the RF signals;

FIG. **2** illustrate a schematic view of a laminated waveguide diplexer for transmitting and receiving radio frequency signals on different frequency bands according to some embodiments of the present disclosure;

FIG. **3** is an exploded view of the laminated waveguide diplexer in FIG. **2**;

FIG. **4** is a close-up view of the laminated waveguide diplexer in FIG. **2**;

FIG. **5** is a cross-sectional view along cross-sectional line **1-1** in FIG. **4**;

FIG. **6** is a close-up view of the laminated waveguide diplexer in FIG. **2**;

FIG. **7** is a cross-sectional view along cross-sectional line **2-2** in FIG. **6**;

FIG. **8** is a close-up view of the laminated waveguide diplexer **10**A in FIG. **2**;

FIG. **9** is a cross-sectional view along cross-sectional line **3-3** in FIG. **8**;

FIG. **10** illustrates a schematic view of a laminated waveguide diplexer for transmitting and receiving radio frequency signals on different frequency bands according to some embodiments of the present disclosure;

FIG. **11** illustrates a schematic view of a laminated waveguide diplexer for transmitting and receiving radio frequency signals on different frequency bands according to some embodiments of the present disclosure;

FIG. **12** illustrates a schematic view of a laminated waveguide diplexer for transmitting and receiving radio frequency signals on different frequency bands according to some embodiments of the present disclosure; and

FIG. **13** is a measured frequency response diagram of the laminated waveguide diplexer in FIG. **2**.

DETAILED DESCRIPTION

The following description of the disclosure accompanies drawings, which are incorporated in and constitute a part of this specification, and illustrate embodiments of the disclosure, but the disclosure is not limited to the embodiments. In addition, the following embodiments can be properly integrated to complete another embodiment.

References to "one embodiment," "an embodiment," "exemplary embodiment," "other embodiments," "another embodiment," etc. indicate that the embodiment(s) of the disclosure so described may include a particular feature, structure, or characteristic, but not every embodiment necessarily includes the particular feature, structure, or characteristic. Further, repeated use of the phrase "in the embodiment" does not necessarily refer to the same embodiment, although it may.

The term "coupled with," along with its derivatives, may be used herein. "Coupled" may mean one or more of the following. "Coupled" may mean that two or more elements are in direct physical or electrical contact. However, "coupled" may also mean that two or more elements indirectly contact each other, but still cooperate or interact with each other, and may mean that one or more other elements are coupled or connected between the elements that are said to be coupled to each other.

The present disclosure is directed to a laminated waveguide diplexer with a shielded signal-coupling structure for transmitting and receiving radio frequency signals on different frequency bands. In order to make the present disclosure completely comprehensible, detailed steps and structures are provided in the following description. Obviously, implementation of the present disclosure does not limit special details known by persons skilled in the art. In addition, known structures and steps are not described in detail, so as not to limit the present disclosure unnecessarily. Preferred embodiments of the present disclosure will be described below in detail. However, in addition to the detailed description, the present disclosure may also be widely implemented in other embodiments. The scope of the present disclosure is not limited to the detailed description, and is defined by the claims.

FIG. **1** shows an RF (radio frequency) lineup block diagram which depicts the RF signals being amplified from a transceiver block **120** to an amplifier module block **130** and radiated to an antenna **143** through a diplexer **141**. The transceiver block **120** includes an MMIC (Monolithic Microwave Integrated Circuit) gain block amplifier **121** and an MMIC bias supply circuitry **123**, and the amplifier module block **130** includes an MMIC gain block amplifier **131**, an MMIC bias supply circuitry **133**, and a high power amplifier **135**. The MMIC gain block amplifier **131** of the amplifier module block **130** is connected to the output of the MMIC gain block amplifier **121** of the transceiver block **120**. Some applications may, among others, use two or more MMIC gain block amplifiers in parallel to generate more power with higher linearity.

FIG. **2** illustrates a schematic view of a laminated waveguide diplexer **10**A for transmitting and receiving radio frequency signals on different frequency bands according to some embodiments of the present disclosure, wherein the diplexer **141** in FIG. **1** can be implemented by the laminated waveguide diplexer **10**A. In some embodiments of the present disclosure, the laminated waveguide diplexer **10**A comprises a first laminated waveguide **20** and a second laminated waveguide **30**.

In some embodiments of the present disclosure, the laminated waveguide diplexer **10**A comprises an upper conductive layer **13**, a bottom conductive layer **15**, and at least one intervening conductive layer **17** disposed between the upper conductive layer **13** and the bottom conductive layer **15**, wherein the first laminated waveguide **20** and the second laminated waveguide **30** are implemented in the upper conductive layer **13**, the bottom conductive layer **15**, and the at least one intervening conductive layer **17**.

In some embodiments of the present disclosure, the first laminated waveguide **20** and the second laminated waveguide **30** may have different lengths, widths and heights, wherein the length and width influences the frequency band while the height influences the quality factor. For example, the first laminated waveguide **20** may have a first length L**1** and a first width W**1** for transmitting and receiving radio frequency signals on a first frequency band, and the second laminated waveguide **30** may have a second length L**2** and a second width W**2** for transmitting and receiving radio frequency signals on a second frequency band.

FIG. **3** is an exploded view of the laminated waveguide diplexer **10**A in FIG. **2**. In some embodiments of the present disclosure, the first laminated waveguide **20** comprises a first upper conductor **21**, a first bottom conductor **23**, at least one first intervening conductor **25** having a first slit **29** disposed between the first bottom conductor **23** and the first upper conductor **21**, and a plurality of first conductive posts **27** arranged along a periphery of the first laminated waveguide **20**. The first conductive posts **27** connect the first bottom conductor **23**, the first intervening conductor **25** and the first upper conductor **21** to form a waveguide structure for transmitting and receiving radio frequency signals. In some embodiments of the present disclosure, the operation frequency band of the waveguide can be further adjusted by the pitch of the posts **27**.

Similarly, the second laminated waveguide **30** comprises a second upper conductor **31**, a second bottom conductor **33**, at least one second intervening conductor **35** having a second slit **39** disposed between the second bottom conductor **33** and the second upper conductor **31**, and a plurality of second conductive posts **37** arranged along a periphery of the first laminated waveguide **30**. The second conductive posts **37** connect the second bottom conductor **33**, the second intervening conductor **35** and the second upper conductor **31** to form a waveguide structure for transmitting and receiving radio frequency signals.

In some embodiments of the present disclosure, the first upper conductor **21** is implemented by a portion of the upper conductive layer **13**, and the second upper conductor **31** is implemented by another portion of the upper conductive layer **13**. In addition, the first bottom conductor **23** is implemented by a portion of the bottom conductive layer **15**, and the second bottom conductor **33** is implemented by another portion of the bottom conductive layer **15**. Furthermore, the first intervening conductor **25** with the first slit **29** is implemented by a portion of the intervening conductive layer **17**, and the second intervening conductor **35** with the second slit **39** is implemented by another portion of the intervening conductive layer **17**.

In some embodiments of the present disclosure, the first laminated waveguide **20** has a first slot **51** in the first upper conductor **21**, the second laminated waveguide **30** has a second slot **61** in the second upper conductor **31**, and the laminated waveguide diplexer **10**A includes a coupling metal **40** having a first line **53** crossing over the first slot **51** and a second line **63** crossing over the second slot **61**. In some embodiments of the present disclosure, the first laminated waveguide **20** has a third slot **71** in the first upper conductor **21** and the laminated waveguide diplexer **10**A includes a third line **73** crossing over the third slot **71**; similarly, the second laminated waveguide **30** comprises a fourth slot **71** in the second upper conductor **31** and the laminated waveguide diplexer **10**A includes a fourth line **83** crossing over the fourth slot **81**. In some embodiments of the present disclosure, the coupling metal **40** further includes a coupling terminal **41** having a first end configured to couple with the antenna **143** and a second end connected to the first line **53** and the second line **63**.

FIG. **4** is a close-up view of the laminated waveguide diplexer **10**A in FIG. **2**, and FIG. **5** is a cross-sectional view along cross-sectional line **1-1** in FIG. **4**. In some embodiments of the present disclosure, the first laminated waveguide **20** has a first via **55** connecting the first upper conductor **21** and the first line **53** of the coupling metal **40**, and the second laminated waveguide **30** has a second via **65** connecting the second upper conductor **31** and the second line **63** of the coupling metal **40**. In some embodiments of the present disclosure, the first via **55** is adjacent to the first slot **51**, and the second via **65** is adjacent to the second slot **61**, such that the first line **53** and the second line **63** are short stubs for the respective radio frequency signals propagating thereon.

In some embodiments of the present disclosure, the laminated waveguide diplexer **10**A comprises a first shielding conductor **211** disposed over the first line **53**, a plurality of first conductive pillars **213** connecting the upper conductive layer **13** and the first shielding conductor **211**, a second shielding conductor **221** disposed over the second line **63**, and a plurality of second conductive pillars **223** connecting the upper conductive layer **13** and the second shielding conductor **223**. In some embodiments of the present disclosure, the first shielding conductor **211** and a second shielding conductor **221** are implemented by different parts of a shielding conductive layer **200**.

In some embodiments of the present disclosure, the first slot **51**, the first line **53**, the first via **55**, the first shielding conductor **211** and the first pillars **213** form a coupling port **50** of the first laminated waveguide **20**. Similarly, the second slot **61**, the second line **63**, the second via **65**, the second shielding conductor **221** and the second pillars **223** form a coupling port **60** of the second laminated waveguide **30**. The characteristic impedance of the transmission line can be adjusted by the width of the signal line; the shielded width of the slot by the signal line; and the height from the upper conductor to the signal line.

FIG. **6** is a close-up view of the laminated waveguide diplexer **10**A in FIG. **2**, and FIG. **7** is a cross-sectional view along cross-sectional line **2-2** in FIG. **6**. In some embodiments of the present disclosure, the first laminated waveguide **20** has a third via **75** connecting the first upper conductor **21** and the third line **73**, wherein the third via **75** is adjacent to the third slot **71** such that the third line **73** is a short stub for the radio frequency signals propagating thereon.

In some embodiments of the present disclosure, the first laminated waveguide **20** has a third shielding conductor **231** disposed over the third line **73** and a plurality of third conductive pillars **233** connecting the upper conductive layer **13** and the third shielding conductor **231**. In some embodiments of the present disclosure, the third slot **71**, the third line **73**, the third via **75**, the third shielding conductor **231**, and the third conductive pillars **233** form a coupling port **70** of the first laminated waveguide **20**.

FIG. **8** is a close-up view of the laminated waveguide diplexer **10**A in FIG. **2**, and FIG. **9** is a cross-sectional view along cross-sectional line **3-3** in FIG. **8**. In some embodiments of the present disclosure, the second laminated waveguide **30** has a fourth via **85** connecting the second upper conductor **31** and the fourth line **83**, wherein the fourth via **85** is adjacent to the fourth slot **81** such that the fourth line **83** is a short stub for the radio frequency signals propagating thereon.

In some embodiments of the present disclosure, the second laminated waveguide **30** has a fourth shielding conductor **241** disposed over the fourth line **83**, and a plurality of fourth conductive pillars **243** connecting the upper conductive layer **13** and the fourth shielding conductor **243**. In some embodiments of the present disclosure, the fourth slot **81**, the fourth line **83**, the fourth via **85**, the fourth shielding conductor **241**, and the fourth conductive pillars **243** form a coupling port **80** of the second laminated waveguide **30**. In some embodiments of the present disclosure, the third shielding conductor **231** and the fourth shielding conductor **241** are implemented by different parts of the shielding conductive layer **200**.

In some embodiments of the present disclosure, the first line **53** serves as a signal-inputting terminal and the third line **73** serves as a signal-outputting terminal for the first laminated waveguide **20**. In addition, the fourth line **83** serves as a signal-inputting terminal and the second line **63** serves as a signal-outputting terminal for the second laminated waveguide **30**; and vice versa. In some embodiments of the present disclosure, the characteristic impedance of the signal lines can be adjusted by changing the width of the signal line, the shielding width of the shielding conductor over the signal line, and the shielding height of the shielding conductor over the signal line.

Consequently, the laminated waveguide diplexer **10**A can use the first laminated waveguide **20** to transmit the radio frequency signals from the antenna **143** to the transceiver block **120** and use the second laminated waveguide **30** to transmit the frequency signals from the transceiver block **120** to the antenna **143**. In addition, the first laminated waveguide **20** and the second laminated waveguide **30** are bidirectional devices, i.e., the second laminated waveguide **30** can be used to transmit the radio frequency signals from the antenna **143** to the transceiver block **120** and the first laminated waveguide **20** can be used to transmit second frequency signals from the transceiver block **120** to the antenna **143**.

FIG. **10** illustrates a schematic view of a laminated waveguide diplexer **10**B for transmitting and receiving radio frequency signals on different frequency bands according to some embodiments of the present disclosure, wherein the diplexer **141** in FIG. **1** can be implemented by the laminated waveguide diplexer **10**B. In contrast to the laminated waveguide diplexer **10**A shown in FIG. **2** having the coupling port **80** disposed in the second upper conductor **31**, the coupling port **80** of the laminated waveguide diplexer **10**B is disposed in the second bottom conductor **33**.

FIG. **11** illustrates a schematic view of a laminated waveguide diplexer **10**C for transmitting and receiving radio frequency signals on different frequency bands according to some embodiments of the present disclosure, wherein the diplexer **141** in FIG. **1** can be implemented by the laminated waveguide diplexer **10**C. In contrast to the laminated waveguide diplexer **10**A shown in FIG. **2** having the coupling port **70** and the coupling port **80** disposed respectively in the first upper conductor **21** and the second upper conductor **31**, the coupling port **70** and the coupling port **80** of the laminated waveguide diplexer **10**C are disposed in the first bottom conductor **23** and the second bottom conductor **33**, respectively.

In some embodiments of the present disclosure, copper or copper alloy, among the other conductive materials, can also be used to form the upper conductive layer **13**, the intervening conductive layer **17**, the bottom conductive layer **15**, the coupling metal **40**, the third line **73** and the fourth line **83**. In addition, a low temperature co-fired ceramic (LTCC) is used to separate the above-mentioned conductive elements according to some embodiments of the present disclosure.

FIG. **12** illustrates a schematic view of a laminated waveguide diplexer **10**D for transmitting and receiving radio frequency signals on different frequency bands according to some embodiments of the present disclosure, wherein the diplexer **141** in FIG. **1** can be implemented by the laminated waveguide diplexer **10**D.

In the laminated waveguide diplexer **10**A shown in FIG. **3**, the first via **55** is adjacent to the first slot **51** such that the first line **53** is a short stub for the first radio frequency signals propagating thereon, the second via **65** is adjacent to the second slot **61** such that the second line **63** is a short stub for the second radio frequency signals propagating thereon, the third via **75** is adjacent to the third slot **71** such that the third line **73** is a short stub for the first radio frequency signals propagating thereon, and the fourth via **85** is adjacent to the fourth slot **81** such that the fourth line **83** is a short stub for the second radio frequency signals propagating thereon. In contrast, the laminated waveguide diplexer **10**D shown in FIG. **12** do not have corresponding vias.

In some embodiments of the present disclosure, the length of the first line **53** is designed to serve as an open stub for the first radio frequency signals propagating thereon, the length of the second line **63** is designed to serve as an open stub for the second radio frequency signals propagating thereon, the length of the third line **73** is designed to serve as an open stub for the first radio frequency signals propagating thereon, and the length of the fourth line **83** is designed to serve as an open stub for the second radio frequency signals propagating thereon. Similarly, the laminated waveguide diplexer **10**B shown in FIG. **10** and the laminated waveguide diplexer **10**C shown in FIG. **11** can use the open stub design in the signal transmission line. In other words, the signal transmission line in the embodiments of the present application can optionally use the open stub design or the short stub design.

FIG. **13** is a measured frequency response diagram of the laminated waveguide diplexer **10**A in FIG. **2**, wherein the waveform with crosses represents the signal response of the first laminated waveguide **20**, and the waveform with dots represents the signal response of the second laminated waveguide **30**. Referring to FIG. **2** and FIG. **12**, in some embodiments of the present disclosure, the first laminated waveguide **20** and the second laminated waveguide **30** have different lengths for transmitting and receiving radio frequency signals on different frequency bands; for example, the first laminated waveguide **20** has the first length L**1** with a pass-band in a range from 74 GHz to 76 GHz, and the second laminated waveguide **30** has the second length L**2** with a pass-band in a range from 84 GHz to 86 GHz.

In addition, the signal magnitude of the second laminated waveguide **30** in the pass-band (74 GHz to 76 GHz) of the first laminated waveguide **20** is substantially lower than −90 dB, i.e., the signals propagating through the first laminated waveguide **20** are not influenced by the signals propagating through the second laminated waveguide **30**. Similarly, the signal magnitude of the first laminated waveguide **20** in the pass-band (84 GHz to 86 GHz) of the second laminated waveguide **30** is substantially lower than −60 dB, i.e., the signals propagating through the second laminated waveguide **30** are not influenced by the signals propagating through the first laminated waveguide **20**.

As a result, the laminated waveguide diplexer can operate in two separated frequency bands instead of a single frequency band; for example, the laminated waveguide diplexer can use one of the two laminated waveguides to receive radio frequency signals on a first frequency band and use another laminated waveguide to transmit radio frequency signals on a second frequency band.

Although the present disclosure and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the disclosure as defined by the appended claims. For example, many of the processes discussed above can be implemented in different methodologies and replaced by other processes, or a combination thereof.

Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present disclosure, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present disclosure. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

What is claimed is:

1. A laminated waveguide diplexer, comprising:
- an upper conductive layer having a first slot and a second slot;
- a first line crossing over the first slot;
- a first shielding conductor disposed over the first line;
- a plurality of first conductive pillars connecting the upper conductive layer and the first shielding conductor;
- a second line crossing over the second slot;
- a second shielding conductor disposed over the second line; and
- a plurality of second conductive pillars connecting the upper conductive layer and the second shielding conductor.

2. The laminated waveguide diplexer of claim **1**, comprising:
- a bottom conductive layer;
- at least one intervening conductive layer having a first slit and a second slit disposed between the upper conductive layer and the bottom conductive layer;
- a plurality of first conductive posts arranged along a periphery of the first slit, wherein the first conductive posts connect the upper conductive layer, the at least one intervening conductive layer and the bottom conductive layer; and
- a plurality of second conductive posts arranged along a periphery of the second slit, wherein the second conductive posts connect the upper conductive layer, the at least one intervening conductive layer and the bottom conductive layer.

3. The laminated waveguide diplexer of claim **1**, further comprising:
- a first via connecting the upper conductive layer and the first line, wherein the first via is adjacent to the first slot, and the first line is a short stub for first radio frequency signals propagating thereon; and
- a second via connecting the upper conductive layer and the second line, wherein the second via is adjacent to the second slot, and the second line is a short stub for second radio frequency signals propagating thereon.

4. The laminated waveguide diplexer of claim **2**, further comprising:
- a third line crossing over a third slot in the upper conductive layer;
- a third shielding conductor disposed over the third line; and

a plurality of third conductive pillars connecting the upper conductive layer and the third shielding conductor.

5. The laminated waveguide diplexer of claim **4**, further comprising:

a third via connecting the upper conductive layer and the third line; and

wherein the third via is adjacent to the third slot, and the third line is a short stub for the first radio frequency signals propagating thereon.

6. The laminated waveguide diplexer of claim **4**, further comprising:

a fourth line crossing over a fourth slot in the upper conductive layer;

a fourth shielding conductor disposed over the fourth line; and

a plurality of fourth conductive pillars connecting the upper conductive layer and the fourth shielding conductor.

7. The laminated waveguide diplexer of claim **6**, further comprising:

a fourth via connecting the upper conductive layer and the fourth line; and

wherein the fourth via is adjacent to the fourth slot, and the fourth line is a short stub for the second radio frequency signals propagating thereon.

8. The laminated waveguide diplexer of claim **6**, further comprising:

a fourth line crossing over a fourth slot in the bottom conductive layer;

a fourth shielding conductor disposed over the fourth line; and

a plurality of fourth conductive pillars connecting the bottom conductive layer and the fourth shielding conductor.

9. The laminated waveguide diplexer of claim **8**, further comprising:

a fourth via connecting the bottom conductive layer and the fourth line; and

wherein the fourth via is adjacent to the fourth slot, and the fourth line is a short stub for the second radio frequency signals propagating thereon.

10. The laminated waveguide diplexer of claim **2**, further comprising:

a third line crossing over a third slot in the bottom conductive layer;

a third shielding conductor disposed below the third line; and

a plurality of third conductive pillars connecting the bottom conductive layer and the third shielding conductor.

11. The laminated waveguide diplexer of claim **10**, further comprising:

a third via connecting the bottom conductive layer and the third line; and

wherein the third via is adjacent to the third slot, and the third line is a short stub for the first radio frequency signals propagating thereon.

12. The laminated waveguide diplexer of claim **10**, further comprising:

a fourth line crossing over a fourth slot in the bottom conductive layer;

a fourth shielding conductor disposed below the fourth line; and

a plurality of fourth conductive pillars connecting the bottom conductive layer and the fourth shielding conductor.

13. The laminated waveguide diplexer of claim **12**, further comprising:

a fourth via connecting the bottom conductive layer and the fourth line; and

wherein the fourth via is adjacent to the fourth slot, and the fourth line is a short stub for the second radio frequency signals propagating thereon.

14. The laminated waveguide diplexer of claim **1**, further comprising a coupling terminal having a first end configured to couple with an antenna and a second end connected to the first line and the second line.

15. The laminated waveguide diplexer of claim **14**, wherein the first line serves as a signal-inputting terminal of a first laminated waveguide and the second line serves as a signal-outputting terminal of a second laminated waveguide.

16. The laminated waveguide diplexer of claim **1**, wherein the first shielding conductor and the second shielding conductor are different parts of a shielding conductive layer.

17. The laminated waveguide diplexer of claim **1**, comprising a first laminated waveguide and a second laminated waveguide having different lengths.

18. The laminated waveguide diplexer of claim **1**, comprising a first laminated waveguide and a second laminated waveguide have different widths.

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